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Occupational Noise Levels of Elevated and Submerged Spray Bars in Aquaculture Tanks

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Abstract

Occupational noise from water flowing into rearing tanks is a common hazard in aquaculture facilities, with long-term exposure potentially injurious to workers. Typical hatchery tank designs have water entering a rearing unit via an elevated spray bar, resulting in considerable turbulence. This study evaluated a novel technique to reduce noise by placing rearing tank spray bars below the water surface. Noise levels were significantly decreased in 1.8-m diameter circular tanks when the spray bar was submerged under the surface of the water. The mean (SE) noise level from tanks with an elevated spray bar was 70.8 (0.1) dB while the mean noise level from tanks with submerged spray bars was 65.0 (0.1) dB. The results of this study indicate that submerged spray bars may be an effective strategy for reducing occupational noise in aquaculture environments.

Keywords

Noise, Spray Bars, Aquaculture, Occupational Safety

1. Introduction

High noise levels are a common occupational hazard. An estimated 22 million people in the United States are exposed to harmful levels of occupational noise each year [1]. High levels of occupational noise over an extended period can result in hearing loss [2]-[5], as well as cardiovascular disease, stress, elevated blood pressure, and decreased work performance [4] [6]-[9].

High noise levels can occur in aquaculture facilities, including fish hatcheries [4] [10]-[13]. Water flowing into rearing units is one of the main sources of occupational noise in aquaculture [10]-[12] [14]. Even if constant noise from flowing water is not hazardous, it can hinder verbal communication [15] [16]. High noise levels may also negatively impact the fish being reared [17]-[22].

Barnes *et al.* [11] described some relatively-simple noise-reducing modifications to hatchery infrastructure, including tank covers and standpipe caps. This study investigated another relatively-simple novel technique to potentially reduce aquaculture occupational noise. Typical hatchery tank designs have water entering a rearing unit via an elevated spray bar, resulting in considerable aeration turbulence and associated noise. However, the effect on noise of submerging the spray bar underneath the surface of the water is unknown. Thus, the objective of this study was to compare the occupational noise levels generated by elevated and submerged spray bars.

2. Methods

This study was performed at McNenny State Fish Hatchery, rural Spearfish, South Dakota, USA. Noise levels were recorded using an Extech Instruments Digital Noise Level Meter Model 407732 (Extech Instruments Corp., Waltham, Oregon). The meter was calibrated at 94.0 dB using an Extech Instruments Sound Level Calibrator (Model 407722) set at the frequency weighting used by the United States Occupational Safety and Health Administration [1]. A low setting and a slow one-second response time optimized the meter to record between 35 and 100 dB [23]. Optimization was conducted to improve the accuracy of the meter within a hatchery environment, where droning sounds are common at uniform decibels. The meter was held at arm's length to reduce any possible effects of reflected sound off the body [24].

This study used six 1.8-m diameter and 78.5-cm deep (60.8 cm water depth) circular fiberglass tanks. Ground water, previously aerated to oxygen saturation at an outside aeration/degassing tower, entered each tank through a 5.08 cm diameter PVC pipe spray bar. The spray bars were 46 cm long with 12 evenly spaced holes for water to enter the tank. Spray bars were set at a slight angle, similar to those used during actual hatchery production to facilitate hydraulic self-cleaning [25]-[27].

Spray bars in three tanks were suspended 12.7 cm above the tank water level, as per the original engineered design (**Figure 1**). Spray bars in three other tanks were submerged so that water entered 5.2 cm below the water surface (**Figure 2**). Tanks were the experimental unit (N = 3). Tanks contained only water.

The aerated well-water entered each tank at a flow rate of 47.8 L/min. Each tank was covered with black corrugated plastic [28], with only a small opening for an automated feeder attached to the side of the tank and suspended above the surface of the water (**Figure 3**). Noise levels were recorded from each tank once a day during weekdays from 7 November 2023 to 7 December 2023. Instantaneous noise levels were recorded approximately 20 cm from the spray bar immediately below the tank cover, approximately 10 cm from the top of the water surface. Noise was measured under the tank cover to minimize background noise impacts; measurements were focused on just the effects of submerged or elevated spraybars. This study was conducted in a production hatchery tankroom using six of 35 tanks. Many of these tanks were being used for fish rearing, so perfect controls for ambient noise were not possible. However, ambient noise levels without water flow-

ing into any of the tanks was previously measured at 50 dB [11]. And by recording noise levels under the tank cover, ambient noise impacts were minimized.

Data was analyzed with repeated measures analysis of variance, with tank as a random effect and day as a repeated factor [29]. All data analysis was done using SPSS (24.0) statistical analysis program (IBM, Armonk, New York), with significance predetermined at $P < 0.05$.

Figure 1. Image of an elevated spray bar in a 1.8-m diameter circular rearing tank.

Figure 2. Image of a submerged spray bar in a 1.8-m diameter circular rearing tank.

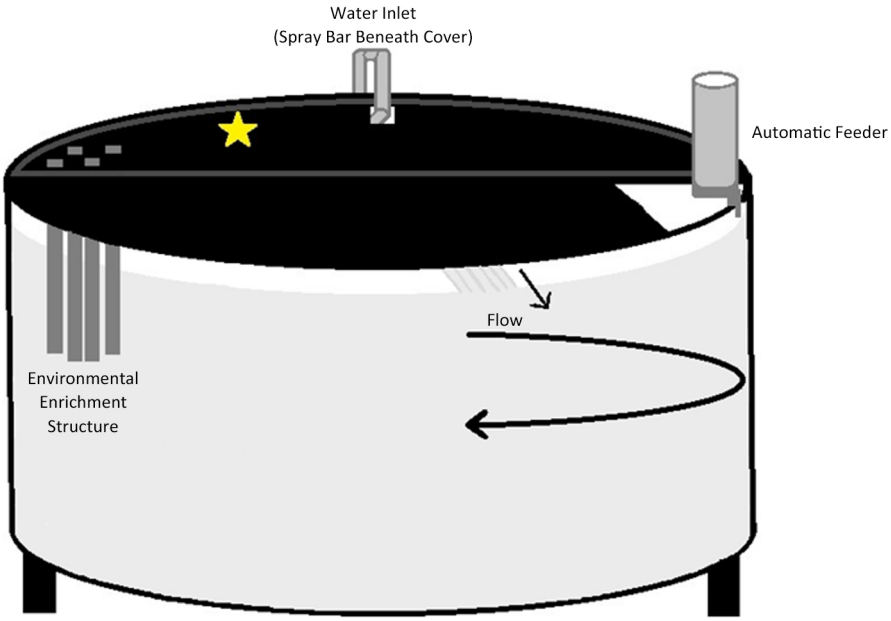

Figure 3. Diagram of a circular tank used for noise measurements. A star is placed where noise readings above the tank occurred. The black portions on the top of the tank denote the corrugated plastic tank covers.

3. Results

Noise levels from the tanks with submerged spray bars were significantly lower than those from tanks with elevated spray bars ($P < 0.001$). The mean (SE) noise level for submerged spray bars was 65.0 (0.1) dB, compared to 70.8 (0.1) dB from the tanks with elevated spray bars. Noise levels from tanks with tanks with submerged spray bars ranged from 63.4 to 66.3 dB, while noise levels from tanks with elevated spray bars ranged from 69.2 to 74.2 dB.

4. Discussion

The results of this study indicate that submerging spray bars are another potential tool to reduce occupation noise levels in aquacultural facilities. If submerging spray bars are used in conjunction with the standpipe caps and tank covers used by Barnes *et al.* [11] to decrease hatchery noise levels, it is likely that many occupational noise concerns could be ameliorated.

There are a range of noise levels in the few hatcheries where noise has actually been measured and reported [11] [12] [30]. In most situations, hatchery noise levels are below the recommended noise level of 85 dB [1] [31]. However, even at levels above 70 dB reported by Barnes *et al.* [11], Voorhees *et al.* [12] and Ngajilo and Jeebhay [30], long-term exposure can lead to occupational hearing loss over time [2] [3] [5] and other negative health impacts [7] [9].

While the results of this study clearly indicate a reduction in noise levels from submerged spray bars at the individual tank level, the combined effects of submerging all the spray bars in a fish rearing building are unknown. It is likely that submerging all spray bars would lead to a dramatic overall noise reduction [32],

but further study is needed to determine how much of a reduction would occur [33].

Aquaculture noise has the potential to affect fish growth and health, although effects are often context-dependent and influenced by species and exposure conditions [7] [18] [19] [21] [22] [34] [35]. Strategies aimed at reducing occupational noise must therefore be evaluated for potential biological trade-offs. In the only study directly comparing elevated and submerged spray bars, Huysman *et al.* [36] reported no negative effects of submerged spray bars on juvenile rainbow trout (*Oncorhynchus mykiss*) growth. In general, elevated spray bars are typically used, but the use of submerged spray bars in conjunction with circular tanks in recirculating aquaculture systems has also occurred with no documented negative effects on fish rearing [37]. This suggests that the noise reduction benefits of submerged spray bars could occur without any impacts on fish rearing performance, but additional research is needed.

In conclusion, submerging spray bars appears to be another technique to reduce noise levels in aquaculture facilities. Additional research is needed to determine its effectiveness at a production scale, both alone and in conjunction with other noise reduction techniques.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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